

**TITLE**

**LOCUS SMOOTHING METHOD AND POINTING DEVICE UTILISING THE  
SAME**

**BACKGROUND OF THE INVENTION**

**5 Field of the Invention**

The present invention relates to a pointing device and a locus smoothing method, and in particular to a pointing device with a locus smoothing function and a locus smoothing method appropriate for the pointing device.

**10 Description of the Related Art**

A mouse is a commonly used input device. A wheel mouse processes a displacement signal, a button signal, and an interface signal and communicates with a computer via a PS2 interface, a universal serial bus (USB) interface, or a wireless communication interface using the mechanical structure of its wheel and a micro-controller chip. An optical mouse replaces the mechanical structure of the wheel mouse with a complementary metal oxide semiconductor (CMOS) photo sensor chip capable of optical navigation. When a mouse moves, its displacement is output to a computer sequentially. While the displacement is digitized by the mechanical structure of the wheel mouse or the CMOS photo sensor chip of the optical mouse to be discrete, rather than continuous in original analog format. If the mouse moves at a small angle or an error occurs in the progress of digitization, a right angle is unavoidable in the locus of the mouse even if the mouse moves slowly and smoothly.

Fig. 1 shows a locus of movement of the conventional mouse. The conventional mouse outputs detected input displacements to a computer without any additional processing. As shown in Fig. 1, I indicates the origin of 5 mouse movement, the input values of displacement are  $P_{11}(1, 0)$ ,  $P_{12}(0, 2)$ ,  $P_{13}(2, 0)$ ,  $P_{14}(1, 0)$ ,  $P_{15}(0, 3)$ ,  $P_{16}(5, 0)$ , and  $P_{17}(0, 5)$ , wherein each input value indicates the displacement from the previous to the current position. When the input values are sequentially output to the 10 computer, the locus of movement of the conventional mouse is a zigzag with some right angles as shown in Fig. 1. This is unacceptable.

#### **SUMMARY OF THE INVENTION**

Accordingly, the present invention provides a pointing 15 device with a locus smoothing function, comprising a locus processing circuit receiving a digitized displacement and executing an accumulation procedure to generate an accumulated value of displacement, wherein when the accumulated value satisfies a preset condition, the 20 accumulated value is output to a processing device for smoothing a locus of a pointer on a display device and a reset procedure is executed to reset the accumulated value.

The present invention also provides a locus smoothing method, appropriate for a pointing device, comprising the 25 steps of receiving a digitized displacement and executing an accumulation procedure to generate an accumulated value of displacement, and determining whether the accumulated value satisfies a preset condition, if so, the accumulated value is output to a processing device for smoothing a locus of a

pointer on a display device and a reset procedure is executed to reset the accumulated value.

A detailed description is given in the following embodiments with reference to the accompanying drawings.

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#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

Fig. 1 shows a locus of movement of the conventional  
10 mouse.

Fig. 2 shows a mouse and a locus processing circuit of the present invention.

Fig. 3 is a flowchart showing the process of a locus smoothing method of the present invention.

15 Fig. 4 shows an allowable region for outputting an accumulated value of displacement of the mouse in the first embodiment of the present invention.

Fig. 5 is a flowchart showing the process for determining whether output of an accumulated value of  
20 displacement of the mouse in the first embodiment of the present invention is allowed.

Fig. 6 is a table showing values generated by the process in Fig. 5.

Fig. 7 shows a locus of movement of the mouse in the  
25 first embodiment of the present invention.

Fig. 8 shows an allowable region for outputting an accumulated value of displacement of the mouse in the second embodiment of the present invention.

Fig. 9 is a flowchart showing the process for determining whether output of an accumulated value of displacement of the mouse in the second embodiment of the present invention is allowed.

5 Fig. 10 is a table showing values generated by the process in Fig. 9.

Fig. 11 shows a locus of movement of the mouse in the second embodiment of the present invention.

#### **DETAILED DESCRIPTION OF THE INVENTION**

10 Fig. 2 shows a mouse 21 and a locus processing circuit 22 of the present invention. As shown in Fig. 2, the mouse 21 comprises a locus processing circuit 22 with a locus smoothing function. Fig. 3 is a flowchart showing the process of a locus smoothing method of the present invention. As shown in Fig. 3, the process starts at step S1. At step S1, the locus processing circuit 22 receives a digitized displacement each time the mouse 21 moves. At step S2, the locus processing circuit 22 executes an accumulation procedure to generate an accumulated value of displacement. In conditional C, the locus processing circuit 22 determines whether the accumulated value satisfies a preset condition, if so, the process continues to the next step S3, if not, the process goes back to step S1 and stays in standby until the next move of the mouse 21.  
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At step S3, the locus processing circuit 22 outputs the accumulated value to a computer for smoothing a locus of a pointer on a monitor of the computer. Final, at step S4, the locus processing circuit 22 executes a reset procedure

to reset the accumulated value and wait for the next move of the mouse 21.

**First embodiment**

In the first embodiment, each time the mouse 21 moves,  
5 the displacement from the previous to the current position is digitized to be an original input value of the mouse 21. The mouse 21 comprises a locus processing circuit 22 further comprising a register (not shown in drawings) and a processing unit (not shown in drawings). The processing  
10 unit accumulates the displacement to yield an accumulated value and stores the accumulated value in the register. Then, the processing unit determines whether output of the accumulated value is allowed.

Fig. 4 shows the allowable region 2B for outputting the  
15 accumulated value of the mouse 21. 2A represents the forbidden region where output of the accumulated value is disallowed. 2B represents the allowable region where output of the accumulated value is allowed. Put simply, if the coordinate value of the accumulated value belongs to the  
20 group of small dots in Fig. 4, output of the accumulated value is disallowed. If the coordinate value of the accumulated value belongs to the group of large dots in Fig. 4, output of the accumulated value is allowed.

Fig. 5 is a flowchart showing the process for  
25 determining whether output of the accumulated value of the mouse 21 is allowed. First, each time the mouse 21 moves, the displacement (X,Y) from the previous to the current position is digitized to be an original input value of the mouse 21 (STEP S1). Next, the displacement is accumulated  
30 to yield the accumulated value (X\_acu,Y\_acu) by executing

formulas  $X_{acu}=X+X_{acu}$  and  $Y_{acu}=Y+Y_{acu}$ . The result is then stored in the register (STEP S2). The processing unit determines whether output of the accumulated value ( $X_{acu}, Y_{acu}$ ) is allowed. The conditional C1 is shown in 5 Fig. 5 as " $X_{acu} \neq 0$  and  $Y_{acu} \neq 0$ ". If the conditional C1 is true, output of the accumulated value ( $X_{acu}, Y_{acu}$ ) is allowed (STEP S3). Then, the processing unit resets the accumulated value ( $X_{acu}, Y_{acu}$ ) to (0,0) and stays in standby until the next move of the mouse 21 (STEP S4). If 10 the conditional C1 is false, the process goes back to the first step S1.

Fig. 6 is a table showing values generated by the process in Fig. 5. For comparison, this embodiment uses the input values of displacement in Fig. 1 as its input values. 15 Therefore, referring to Fig. 1, I indicates the origin of mouse movement, the input values are  $P_{11}(1,0)$ ,  $P_{12}(0,2)$ ,  $P_{13}(2,0)$ ,  $P_{14}(1,0)$ ,  $P_{15}(0,3)$ ,  $P_{16}(5,0)$ , and  $P_{17}(0,5)$ , wherein each input value indicates the displacement from the previous to the current position. As shown in Fig. 6, when 20 the accumulated value is (1,2), (3,3), or (5,5), the conditional C1 in Fig. 5 is true, thus output of the accumulated value is allowed. In addition, referring to Fig. 4, the accumulated values (1,2), (3,3), and (5,5) all belong to the group of large dots in the allowable region 2B 25 where output of the accumulated value is allowed, in accordance with the process in Fig. 5.

Fig. 7 shows a locus of movement of the mouse 21 of the present invention. As shown in Fig. 7, when the accumulated values  $P_{51}(1,2)$ ,  $P_{52}(3,3)$ , and  $P_{53}(5,5)$  are sequentially 30 output to the computer, the locus of movement of the mouse.

21 is represented by the connection line from I to P51, P52, and P53 as the solid line therein. Compared with the locus without additional processing (as indicated by the dotted line in Fig. 7), the locus of this embodiment (as indicated 5 by the solid line in Fig. 7) has fewer right angles and smoother movement.

#### Second embodiment

In the second embodiment, each time the mouse 21 moves, the displacement from the previous to the current position 10 is digitized to be an original input value of the mouse 21. The mouse 21 comprises a locus processing circuit 22 further comprising a register (not shown in drawings) and a processing unit (not shown in drawings). The processing unit accumulates the displacement to yield an accumulated 15 value and stores the accumulated value in the register. Then, the processing unit determines whether output of the accumulated value is allowed.

Fig. 8 shows the allowable region 6B for outputting the accumulated value of the mouse 21. 6A represents the 20 forbidden region where output of the accumulated value is disallowed. 6B represents the allowable region where output of the accumulated value is allowed. Put simply, if the coordinate value of the accumulated value belongs to the group of small dots in Fig. 8, output of the accumulated 25 value is disallowed. If the coordinate value of the accumulated value belongs to the group of large dots in Fig. 8, output of the accumulated value is allowed.

Fig. 9 is a flowchart showing the process for determining whether output of the accumulated value of the

mouse 21 is allowed. First, each time the mouse 21 moves, the displacement (X,Y) from the previous to the current position is digitized to be an original input value of the mouse 21 (STEP S1). Next, the displacement is accumulated 5 to yield the accumulated value ( $X_{acu}, Y_{acu}$ ) by executing formulas  $X_{acu}=X+X_{acu}$  and  $Y_{acu}=Y+Y_{acu}$ . The result is then stored in the register (STEP S2). The processing unit determines whether output of the accumulated value ( $X_{acu}, Y_{acu}$ ) is allowed. The first conditional C2 is shown 10 in Fig. 9 as " $X_{acu} > 4$  or  $Y_{acu} > 4$ ". If the first conditional C2 is true, output of the accumulated value ( $X_{acu}, Y_{acu}$ ) is allowed (STEP S3). Then, the processing unit resets the accumulated value ( $X_{acu}, Y_{acu}$ ) to (0,0) and stays in standby until the next move of the mouse 21 (STEP 15 S4). If the first conditional C2 is false, the process continues to the second conditional C3. The second conditional C3 is shown in Fig. 9 as " $X_{acu} \neq 0$  and  $Y_{acu} \neq 0$  and ( $X_{acu}>2$  or  $Y_{acu}>2$ )". If the second conditional C3 is true, output of the accumulated value ( $X_{acu}, Y_{acu}$ ) is 20 allowed (STEP S3). Then, the processing unit resets the accumulated value ( $X_{acu}, Y_{acu}$ ) to (0,0) and stays in standby until the next move of the mouse 21 (STEP S4). If the second conditional C3 is false, the process returns to the first step S1.

25 Fig. 10 is a table showing values generated by the process in Fig. 9. For comparison, this embodiment uses the input values of displacement in Fig. 1 as its input values. Therefore, referring to Fig. 1, I indicates the origin of mouse movement, the input values are  $P_{11}(1,0)$ ,  $P_{12}(0,2)$ ,

P<sub>13</sub>(2,0), P<sub>14</sub>(1,0), P<sub>15</sub>(0,3), P<sub>16</sub>(5,0), and P<sub>17</sub>(0,5), wherein each input value indicates the displacement from the previous to the current position. As shown in Fig. 10, when the accumulated value is (3,2), (1,3), (5,0), or (0,5), the 5 first conditional C2, the second conditional C3, or both in Fig. 9 is true, thus output of the accumulated value is allowed. In addition, referring to Fig. 8, the accumulated values (3,2), (1,3), (5,0), and (0,5) all belong to the group of large dots in the allowable region 6B where output 10 of the accumulated value is allowed, in accordance with the process in Fig. 9.

Fig. 11 shows a locus of movement of the mouse 21 of the present invention. As shown in Fig. 11, when the accumulated values P<sub>91</sub>(3,2), P<sub>92</sub>(1,3), P<sub>93</sub>(5,0), and P<sub>94</sub>(0,5) 15 are sequentially output to the computer, the locus of movement of the mouse 21 is represented by the connection line from I to P<sub>91</sub>, P<sub>92</sub>, P<sub>93</sub>, and P<sub>94</sub> as the solid line therein. Compared with the locus without additional processing (as indicated by the dotted line in Fig. 11), the 20 locus of this embodiment (as indicated by the solid line in Fig. 11) has fewer right angles and smoother movement.

It is to be understood that the invention is not limited to the disclosed conditionals C1, C2, and C3 in Figs. 5 and 9. Any appropriate conditional can be used by 25 the processing unit of the mouse 21 of the present invention to output various accumulated values to the computer, thereby smoothing the locus of movement of the mouse 21.

While the invention has been described by way of example and in terms of the preferred embodiments, it is to 30 be understood that the invention is not limited to the

disclosed embodiments. To the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the 5 broadest interpretation so as to encompass all such modifications and similar arrangements.